UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Distr.
LIMITED
UNIDO/IS.448
24 February 1984
ENGLISH

STRATEGIES FOR INCREASING THE PRODUCTION OF TANNING CHEMICALS IN DEVELOPING COUNTRIES

Sectoral Working Paper Series

No. 17

Sectoral Studies Branch
Division for Industrial Studies

SECTORAL WORKING PAPERS

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Preface

This study has been prepared by UNIDO's Division for Industrial Studies, Sectoral Studies Branch. It represents a first attempt at describing the production of tanning chemicals on a world-wide basis. Specific emphasis is put on an appraisal of the opportunities for the developing countries to increase their share in the production of chemicals for the leather and leather industry.

The study builds upon the estimated and projected production of raw hides and skins, leather, and leather footwear in "The leather and leather products industry: Trends, prospects and strategies for development", UNIDO/IS.442, February 1984. The variety of existing tanning processes and non-uniformity of leather statistics, however, has not allowed exact calculations of chemical requirements. The lack of specific data for this sector is serious.

The study is intended as a background document to the Third Consulation on the Leather and Leather Products Industry to be held at Innsbruck, Austria from April 16 to 20, 1984. It is issued in the Sectoral Working Paper Series. Such papers are more explanatory and tentative than those issued in the Sectoral Studies Series and are, as a rule, subject to revisions and modifications. It is expected that the present study will be revised after the Third Consultation, taking into account the outcome of the Consultation as well as further research work.

The study is based on a consultant input of Bessell Associates, Loughborough, England and information available to UNIDO.

EXPLANATORY NOTES

References to dollars ($) are to United States dollars, unless otherwise stated.

A comma (,) is used to distinguish thousands and millions.

A full stop (.) is used to indicate decimals.

A slash between dates (e.g., 1980/81) indicates a crop year, financial year or academic year.

Use of a hyphen between dates (e.g., 1960-1965) indicates the full period involved, including the beginning and end years.

Metric tons have been used throughout.

The following forms have been used in tables:

Three dots (...) indicate that data is not available or is not separately reported.

A dash (-) indicates that the amount is nil or negligible.

A blank indicates that the item is not applicable.

Totals may not add up precisely because of rounding.

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1. INTRODUCTION

The tanning industry has certain distinctive features which are common to many developed and developing countries. The industry can usually be based on domestically available raw material. The cost of the hide normally constitutes up to 60 per cent of the final value of the product while the cost of chemicals constitutes between 10 and 15 per cent. Business margins are generally low.

Developing countries that are planning to enter the tanning industry have to import large quantities of chemicals, some of which are of specialized nature. Certain general purpose chemicals used in tanning such as lime and sulphuric acid may be available locally, but most developing countries must import specific chemicals, including chrome tanning materials, synthetic tanning materials and leather finishes. Specialized tanning chemicals require skills and experience to use and for this reason manufacturers offer full technical assistance to ensure their proper application. Many leather chemicals are used in the tannery in complex mixes adjusted to suit local conditions, the types of leather being produced, and the raw material being processed.

There has been considerable development of leather chemical manufacture in developing countries with large tanning industries, mostly through co-operation with large European or North American manufacturers. While chromium compounds are found in the developing world, opportunities for their local production for tanning purposes have been strictly limited. Scope for the use of indigenous tanning materials has been limited but it does exist in relation to bulk chemicals, vegetable tanning extracts, certain types of retanning materials, fat liquors and fillers. Their expanded utilization should be possible if the value of leather as a natural material is to be emphasized and if the effluent problems associated with the use of chromium are to be reduced.

The tanning chemicals are derived from a variety of fundamentally different chemical processes. Therefore, different constraints and opportunities face the developing countries in expanding or starting up their own manufacturing in this sector, depending upon the source industry. Certain

possibilities, such as vegetable tanning materials, fat liquors (based on a vegetable and animal fats and oils industry) might very well be feasible for production, particularly on a regional scale. On the other hand, chemical dye stuff, syntans and chrome salts offer limited possibilities because of complex process technology and/or current patent rights. Of course, if a country is already making dyes for the textile industry, it is possible to diversify into leather dyes.

Figure 1.1 summarizes the possibilities for the developing countries to participate in the production of tanning chemicals. The report itself goes into considerably more detail although quantitative estimation is not possible without a considerably improved data base and further studies, some of which are outlined in the last section of the report.

This report's major objective is to consider the prospects of increasing the production of tanning chemicals in developing countries. As background information against which to consider this objective the estimates of the likely pattern of leather production to the year 2000 for each of the major world developing regions, made in a companion study, have been used.1/

There are no published world-wide reports dealing specifically with tanning chemicals, perhaps because of great difficulties in identifying the final use of most chemicals. Thus, most of the chemicals involved in the tanning industry are not made especially for use by this industry but have many other important, and often major, uses in other industrial sectors. Moreover, recent and sufficiently detailed statistics of total production of chemicals are not readily available for many countries and in some cases they do not exist.

Table 1.1 gives, for certain developing countries, some very rough estimates of the proportions of tanning chemicals used that are domestically produced. These estimates are based upon scattered information that has reached the UNIDO secretariat from a variety of sources. They should be regarded as illustrative only.

1/ The leather and leather products industry: Trends, prospects and strategies for development, UNIDO/IS.442, February 1984.

Figure 1.1. Possibilities for developing countries to participate in the production of tanning chemicals by 2000

Category	Could developing countries produce?	Possibilities for developing countries to produce successfully with limited technical assistance	Growth to 2000
Basic tanning chemicals			
Ammonia Sodium sulphide Ammonium chloride Sulphuric acid Sodium carbonate	depends on chemical industry infra-structure	possible	growth expected
Sodium chloride Calcium oxide/hydroxide	if materials available	possible	growth expected
Tanning chemicals			
Chromium sulphate Vegetable tanning materials	difficult if materials available	very difficult possible	nil declining but opportunities could develop
Syntans[a/]	yes	restricted; petro-chemical or steel industries required	growth expected
Dyestuffs	yes	restricted; skills and experience needed which is difficult to transfer	growth expected
Oils and fatliquors[a/]	yes	good for sulphated oils	growth expected
Finishes[a/]	difficult	restricted; petro-chemical or steel industries required	growth expected

a/ Comments do not refer to mixing of chemicals.

Note: The use of soaking agents and surfactants has not been taken into account.

Table 1.1. Estimate of developing countries' production of various tanning chemicals as percentage of their total consumption

Country	General chemicals	Chrome salts	Syntans	Fat liquors	Dyes	Finishing materials
Mexico	100	100	80	...	40-50	50
Brazil	100	100	90	80-90	80	90
Argentina	100	100	75	...	70	60
Colombia)						
Chile)						
Peru)	...	100	80-90	...	40	20
Venezuela)						
India	100	100	90	100	60	80
Pakistan	...	30	...	...	...	...
Republic of Korea	...	...	...	30	10-20	10-20
People's Republic of China	100	100	...	...	50	...
Egypt	...	small	...	small	small	...
Morocco	...	...	...	small	...	small

Table 1.2. Trade balances for selected chemicals, 1981[a/]

(thousand tons)

Chemical/material (1)	Developed market economies (2)	Developing market economies (3)	CPE Europe and Asia (4)
General purpose chemicals			
Sodium sulphide[b/]	-25	+2	?
Calcium hydroxide[c/]	-17	-	+17
Sodium chloride	+5,554	+3,782	-9,336
Sulphuric acid[d/]	-503	+507	small
Sodium carbonate[b/]	-132	+458	?exports
Basic tanning materials			
Vegetable tanning materials	+36	-81	+45
Performance materials			
Syntans	-82	+6	+76
Fatliquors[c/ e/]	-13	small	?
Dyes[f/]	-84	+29	+55

Source: Board of Trade Library, London; various country publications.

a/ + indicates net imports; - indicates net exports.

b/ Column (2): excludes North America.

c/ Includes calcium oxide.

d/ Column (3): excludes Africa.

e/ Only animal and vegetable fats included under SITC (Revision 2) code 431.2.

f/ Synthetic organic dyestuffs only.

Table 1.2 provides summarized trade data for certain tanning chemicals. Trade statistics do not always separately identify the chemicals for which information is needed. For some countries trade statistics do not exist; for others the statistics are so obviously in error that no faith can be placed on the reported figures. Table 1.2 gives (incomplete) trade balances for selected chemicals in 1981.

A number of European chemical companies and other interested organizations assisted the investigation by providing their views on various aspects of the study. In two cases the companies were willing to provide information on chemical use within the tanning industry. These estimates have been of assistance in providing essential background information.

Estimates of requirements of chemicals used in the leather industry in this report are based on two categories of leather, viz. "heavy bovine leather" and "light leather" from all sources considered (i.e. bovine, sheep and lambs, goats and kids). Production of leather from pigskins has not been included in this reports.

2. PRODUCTION OF LEATHER TO 2000

The estimated production of leather to the year 2000 is shown in detail in annex, table A1. The following table summarizes the results:

Table 2.1. Total leather production 1980 to 2000[a/]

Region	Heavy leather thousand tons			Light leather million sq.ft		
	1980	1990	2000	1980	1990	2000
Developed market economies	143	130	123	4,341	4,572	4,813
CPE - Europe (incl. USSR)	162	140	105	1,893	2,195	2,500
Developing market economies	161	190	216	4,048	5,115	6,335
CPE Asia	37	40	46	614	728	828
World	504	500	490	10,896	12,610	14,475

a/ Numerical discrepancies in this, and other text tables, are due to rounding differences.

Source: The leather and leather products industry: Trends, prospects and strategies for development, UNIDO/IS.442, February 1984.

A small decline in the world production of heavy leather is envisaged between 1980 and 2000 of about 2.8 per cent from 504 to 490 thousand tons. This will be accompanied by an increase in light leather of almost a third, given an anticipated slightly higher increase of light leather from bovine animals than from sheep and goats. This development implies a continuation of the decline in vegetable tanned heavy leather in the developed market economies and the CPE, although the decline has slowed in the early eighties.

The amo nt of chemicals and other materials needed to produce leather has been calculated on the basis of units of hide produced (see annex, table A2) so it has been necessary to convert leather produced into raw hide equivalent. The conversion factors used are shown in annex, table A3. The raw hide necessary to produce the leather is shown in annex, table A4 and the results are summarized below:

Table 2.2. Raw hide necessary to achieve production of leather 1980, 1990 and 2000

(thousand tons)

Region	Heavy leather			Light leather		
	1980	1990	2000	1980	1990	2000
Developed market economies	264	238	226	2,542	2,757	2,966
CPE - Europe (incl. USSR)	298	258	193	1,188	1,401	1,615
Developing market economies	297	350	397	2,381	3,011	3,675
CPE Asia	69	74	85	354	430	502
World	928	920	901	6,465	7,599	8,758

Source: Table 2.1 and The leather and leather products industry: Trends, prospects and strategies for development, UNIDO/IS.442, February 1984.

Patterns of change in raw hide production between 1980 and 2000 follow, naturally, those for leather production. An increase of one-third in heavy leather production is expected in developing market economies and 23 per cent in CPE Asia. The quantity of raw hides for light leather will increase in all regions but with the developing market economies providing 1,294 thousand tons of the world increase of 2,293 thousand tons for light leather, the figures underline the opportunities which will exist for some developing countries to process more raw hide than hitherto. Not only will the supply of hides increase but also the home market demand for leather in developing countries, reaching towards a more viable situation than hitherto for local production of, at least some, tanning chemicals or other materials.

By the year 2000 there will be a shortage of leather from the major sources of bovine, ovine and caprine stock to satisfy the demand rates for leather per capita if demand for types of leather products continue in their current patterns. The developing market economies are likely to see their 1980 export potential (in terms of leather) of about 1,100 million sq.ft change into an import requirement of 380 million sq.ft. The developed market economies and CPE countries will also require to import almost 3,700 million sq.ft if their demands are to be met. Clearly, not all markets will be

satisfied from the current major sources of supply. This is likely to put considerable strain on some of those economies which have strong shoe industries, large tanning capacity, but little domestic raw material. If no change in the pattern of supply and demand occurs, the rising price of leather may make it more profitable for those with significant raw material exports to consider a higher degree of local processing.

3. TANNING CHEMICALS: PROPERTIES AND USES

The tanning of leather is a mixture of art and craft. The chemicals a tanner uses relate to his own skills, his preferences, the raw stock he is using, and the end use for the leather he is making. In many areas a tanner has a choice of chemicals to use and will prefer one to another because it offers minor advantages or avoids what he considers minor disadvantages. Often he will use his own specific combinations to get the best results. His overall process becomes a balance of various chemical additions to achieve a final leather type. Table 3.1 shows where in the process the major chemicals are most commonly used in leather processing.

The chemicals shown in table 3.1 present a somewhat wide choice of alternatives, so it has been necessary to select some most commonly used chemicals for the purpose of estimation of requirements for tanning. The 19 selected chemicals are shown in annex, table A2. The notes below explain, briefly, the properties and uses of the 19 selected chemicals.

3.1 General purpose chemicals

3.1.1 Sodium sulphide

The liming process in the tannery is designed to destroy the hair and epidermis completely or to loosen them so that they can be easily removed mechanically. Liming normally involves using both hydrated lime and sodium sulphide. The sodium sulphide is considered to be essential for the depilation action. Occasionally the sodium sulphide is replaced in whole or part by sodium hydrosulphide (NaHS), but by far the major consumption is in sodium sulphide.

Sodium sulphide is a dangerous chemical to handle and to use. It is one that tanners are normally required to remove from the effluent before passing it onto sewers or rivers. This is often neglected in the developing countries to the detriment of their environment.

Figure 3.1. Summary of chemicals and chemical products used in production of tanned leather

		Chemicals used (not exhaustive)
1	Preservation	Sodium chloride (NaCl), bactericides
2	Beamhouse work:	
	Soaking Unhairing Liming	Sodium sulphide, Na_2S Calcium hydroxide, $Ca(OH)_2$
3	Deliming Bate	Hydrochloric acid, HCl Ammonium chloride, NH_4Cl Ammonium sulphate, $(NH_4)_2SO_4$ Sodium bisulphite, $NaHSO_3$ Enzymatic bate in ammonium salts
4	Pickling	Sodium chloride, NaCl Sulphuric acid, H_2SO_4
5	Tanning:	
	(a) Mineral	Chrome salts, mostly in the form of chromium sulphate, $Cr_2(SO_4)_3$ Basification with sodium carbonate, Na_2CO_3, or sodium bicarbonate, $NaHCO_3$
	(b) Vegetable	Vegetable tanning materials
6	Neutralisation	Sodium sulphite, Na_2SO_3 Calcium formate, $Ca(HCOO)_2$ Sodium bicarbonate, $NaHCO_3$
7	Retanning	Synthetic tanning materials (syntans)
8	Dyeing	Natural and synthetic dyes Ammonia, NH_3 Formic acid, HCOOH
9	Fatliquoring	Natural or synthetic oils
10	Finishing	Acrylic resins Pigments Nitrocellulose lacquers Solvents Polyurethanes

Sodium sulphide is made chemically by passing hydrogen sulphide into caustic soda solution, by heating hydrosulphide, or by heating sodium sulphate with coal in a revolving furnace. In this latter case the sodium sulphate or "salt-cake" is a by-product of hydrochloric acid manufacture. Sodium sulphide is a buff coloured solid. Its main use is in the production of dyes after which its use in tanning is next in importance.

3.1.2 Calcium hydroxide

Calcium oxide (CaO) is quicklime which is changed into slaked lime (calcium hydroxide) by adding water. Slaked lime is more commonly used in tanneries in its powdered form as hydrated lime. Lime is used in large quantities in a process called "liming" which is a swelling, hair loosening and removal process. In addition to swelling the hide, the lime attacks and destroys most of the non-leather forming structures in the skin. The lime liquors prepare the hide or skin for further processing and allows the pelt to take up the proper amount of tanning agent.

Calcium hydroxide has many industrial uses including being the basis for mortar and an important chemical component in many other industrial sectors. In addition it is used to make bleaching powder, caustic soda, in sugar purification, in glass making and in the recovery of ammonia.

Quicklime or calcium oxide is made on a large scale by heating calcium carbonate. The latter is the basis of chalk, limestone and marble. Thus it is readily available in enormous quantities, with mountain ranges entirely made of chalk, calcite, limestone and dolomite. The limestone or chalk is normally burnt in controlled kilns. Some limestones contain iron and magnesium compounds, plus clay if they are obtained from a 'blue lias' strata. These impurities form a compound similar to cement when heated. Although beneficial for building purposes this interferes with the slaking process, and produces large amounts of sludge. As already noted tanners normally use lime in the slaked lime form of calcium hydroxide.

A major problem of lime from local quarries and local plants in developing countries is its lack of purity. Frequently the lime is found to

contain a lot of large abrasive particles, such as stones or sand. These particles scuff the surface off the hides or skins making the leather unsuitable for high quality selections.

3.1.3 Hydrochloric acid

This is a strong acid sometimes used to assist in the deliming stage. Most hydrochloric acid is manufactured by burning hydrogen with chlorine in the absence of ultra violet light. Chlorine itself is obtained by the hydrolysis of brine (NaCl Solution). It can also be made by heating NaCl (common salt) with sulphuric acid. The by-product of this reaction is "salt-cake" which can be used to make sodium sulphide as previously described.

Hydrochloric acid is used for a number of industrial uses, including the dyestuff industry. In diluted form it is used for purifying coke, iron ores and clay, and for "pickling" sheet iron in the galvanising and tin plate industries. It is also used in the manufacture of some chlorides.

3.1.4 Ammonium sulphate

Ammonium sulphate is a weak deliming agent. It is used to delime pelts, sometimes on its own but occasionally together with hydrochloric acid or speciality proprietary products.

Ammonium sulphate is a major volume import into many developing countries as a fertilizer. It is also used as a source of ammonia compounds. In its manufacture ammonia is passed into sulphuric acid and the ammonium sulphate is obtained by evaporation. Another industrial method of manufacture is by the action of ammonia and carbon dioxide on calcium sulphate in the presence of hot water.

3.1.5 Sodium bisulphite

This product is also known as sodium hydrogen sulphite. It can be used as a deliming agent, and also has a bleaching effect. It can be made by passing sulphur dioxide into a hot solution of sodium carbonate. It has uses as an antiseptic for preserving food, and as an antichlor.

3.1.6 Sodium chloride

Sodium chloride, or common salt, is used in the preservation of raw hides and skins and in the pickling process. In the most common method of preservation, salt is thrown onto the flesh side of the raw hides which are left standing in piles for about seven to 10 days. During this time the salt dehydrates the hide, and the concentration of NaCl prevents bacteria growth. The amount of salt used is between 30 and 40 per cent of the raw weight of the hide and the hide takes up from 15 to 25 per cent of the salt used. In some countries the salt is applied via a concentrated brine solution. In countries where salt is unobtainable, or difficult to obtain, the hides are preserved by drying in sun or shade or by a combination of salting and drying. These methods tend to lose hide substance and actually lead to a poorer quality leather than that which would have been obtained by proper salting. A number of wet blue tanneries have been built in recent years to process hides directly from the abattoir which avoids this preservation process.

Salt is also used in the pickling process which comes after the hair has been removed, a process which occurs prior to tanning. Pickling uses acid and salt and the salt prevents excessive damage and swelling while the acid changes the pH of the pelt, preparing it for the tannage itself. With sheepskins the pickled stage is a major state in which "pickled pelts" are traded internationally.

Apart from use in foodstuffs and as a preservative, very large quantities of salt are used in the manufacture of chlorine, of sodium carbonate and of caustic soda. Use in the world tanning industry forms a very small part of world consumption of salt. In some developing countries, for example in Africa and Central America, salt is nevertheless an important consideration for tanners. Although tanners do use marine salt, they prefer rock salt. Sea salt contains halophilic bacteria which can develop red heat in stored hides and lead to considerable damage.

Problems related to the supply of salt, and to the difficulty in removing it from the effluent are considered likely to have a restrictive impact on the development of the African leather industry.

3.1.7 Calcium formate

Calcium formate is used as a neutralizing agent at the start of retanning. A number of alternative products can also be used including sodium formate, sodium bicarbonate and sodium sulphite. Chemical companies associated with the leather trade also have a variety of proprietary products.

3.1.8 Sulphuric acid

Sulphuric acid is a strong inorganic acid used mostly for pickling prior to tanning. Some tanners prefer to carry out the reduction process (conversion of hexavalent dichromate to trivalent chromium sulphate) by themselves, in which process sulphuric acid is also required. Many tanneries like to soften the effect of the strong acid by using softer acids such as the weak organic lactic acid.

Sulphuric acid is classed as a most important industrial acid and it is manufactured in many parts of the world by a variety of processes. It is used in the manufacture of explosives, fertilizers and dyestuffs. The amount consumed in the leather industry is very small by comparison with other industrial uses.

3.1.9 Sodium carbonate

Sodium carbonate is known as soda or soda ash. It is used for basifying the chrome tanning salts after they have penetrated the hides and skins in the tanning process. This fixes the chrome and completes the tanning itself. Sodium bicarbonate is used as a basifying and neutralizing chemical in the tannery. It is made commercially by saturating a moist mush of carbonate crystals with carbon dioxide. Some tanneries prefer to use sodium bicarbonite which is less stringent and less risky for the leather quality in use. Both chemicals have very common alternative uses, much more important than tanning. Sodium carbonate is also used as a neutralising agent at the start of retannage. Larger quantities of sodium carbonate are used in the manufacture of caustic soda, of glass, of sodium silicate and of borax. It is also used for softening water and as a constituent of soap powders. Sodium bicarbonate is used in health salts and baking powder.

3.1.10 Sodium sulphite

Sodium sulphite can be used as a neutralizing agent, and gives an even penetration. Similar to sodium bisulphite, sodium sulphite is used as a preservative for foodstuffs. It is also used in photography, in the refining of sugar and as a bleaching agent for wool and silk. It is a white powder made by reacting sulphur dioxide with sodium carbonate or sodium hydroxide.

3.2 Basic tanning chemicals

3.2.1 Chromium sulphate

In the manufacture of leather the essential process is the tanning process itself, which converts the fibre structure of the hide or skin into a material which will not putrefy and is stable for use in shoes, garments and leather goods.

Until 100 years ago the vast majority of tanning was done using natural materials of a vegetable base. In the last 100 years mineral tannages have been introduced and have become of prime importance. Mineral tanning agents include such materials as aluminium and zirconium, but by far the most commonly used agents are chromium compounds, actually mainly chromium sulphate.

Chrome can be used by tanners in a number of forms. These include sodium bichromate, chrome alum, potassium bichromate, and chromium sulphate. Most commonly used today is the basified form of chromium sulphate ($Cr_2(SO_4)_3$). The basification relates to the activity of the chromium for crosslinking leather fibres. There are a number of ways of preparing chrome tanning materials so the strength of the product is measured in terms of chromic oxide (Cr_2O_3). The product is produced in the liquid form but it is normally spray-dried and sold as a powder in most countries.

Of all the individual chemicals in use in the world's tanning industry chromium is the most important, both in terms of cost and strategic importance. Considering the state of the science of tanning, a reduction in the availability or supply of chrome materials would have very serious implications.

Chromium is a strategic material and some of the OECD countries have a declared policy of stockpiling. It is obtained from chromite, the only important ore of chromium. The major countries where chromite is obtained are Malawi, South Africa, Turkey, the USSR, Zambia and Zimbabwe. As usually obtained, it contains small amounts of carbon, and is one of the hardest common metals.

Chromium has three areas of use being refractory, metallurgical (the main reason for its strategic importance), and chemical. It is estimated that 25 per cent of chromium chemicals produced are used for chrome tanning. A similar quantity is used in plating, including chrome plating, iron dips, anodizing aluminium, and other associated uses. Chromium chemicals are also used in photography, dyestuff manufacture and a great variety of other purposes.

3.2.2 Vegetable tanning extracts

Vegetable extracts were the original tanning materials; most vegetable extracts contain some tannins. Quebracho, mimosa and chestnut (often referred to as QMC) are the most used. Valonia, oak, sumac, myrobalano, mangrove, dividivi and many others can be, and are used. They are prepared from certain parts of the particular plants. These can be the leaves, roots, bark, wood, fruits or even growths. Tanning extracts have other uses, the most noted of which is in drilling muds where quebracho is used. However, the tanning industry is by far the major user. Vegetable tanning materials are used as the major, if not only, tanning material in the manufacture of sole leather and other heavy leathers being sold by weight. The extracts are also used by chrome tanners in the retanning stage.

3.2.3 Vegetable aluminium tannings

Before ending this section it is necessary to mention vegetable aluminium processes. Since the turn of the century, tannage with chromium salts has grown to be by far the major single tannage used for the world's leather industry. Traditional tannage by vegetable tanning materials has declined dramatically and now remains in use as a basic tannage only for sole leather

and some specialized industrial and upholstery leathers. The dependency of the leather industry on chromium salts has, during the last decade, become a matter of concern for leather producers throughout the world. The countries of supply are limited. Chromium creates effluent problems in both liquid and solid wastes.

Chromium was initially preferred because it allowed faster processing and gave leather better ability to stand the high temperatures of some modern shoemaking methods. Today, rapid processing methods for vegetable tans are also available, and with the increased demand for natural high quality leathers, not all of which need high levels of heat resistance. There is a possibility that vegetable tanning could start to take a larger share of the tanning rather than continue to decline as presently predicted. There is already some evidence of this in the developed countries. In addition a considerable amount of research was carried out in the late seventies and early eighties into other systems of tannage that might be substituted for chrome tannage. Some of the most interesting is the use of aluminium salts in place of chromium salts.

Alum tanned leather is pure white and has special stretch characteristics which made it suitable for gloving, clothing and fur skins. To avoid emptiness it used to be applied with a mix of common salt, flour and egg yolk. These processes were used well into the present century and some sport leather, e.g. cricket balls are still alum tanned.

The new work[2/] with aluminium involves trying to avoid the problems of poor water resistance and maintain qualities without the use of flour and egg yolk. The most successful work has been carried out by the BLMRA in England, CSIRO in Australia, and LIRI in South Africa and combined aluminium with various vegetable tanning materials.

2/ Sykes and Cater, JSLTC, 1980, 64(2), 29. Covington and Sykes, JSLTC, 1981, 65(2), 21. Cutting, Proceedings of the Congress on the Leather Industry, Budapest, 1982.

While still in the process of development these "semi-alum" or vegetable aluminium (mostly "mimosa Al") processes may well have a considerable effect on chemical consumption over the next twenty years.

3.3 Performance chemicals

3.3.1 Bates

Bating is a process designed to render limed hide softer and more supple. The plumpness of liming is removed and unwanted matter between the fibres is also dislodged and removed, enhancing the "breathing" characteristics of the leather.

Originally this process was called "puering" and a warm infusion of dog dung was used. When hen or pigeon dung was used the term applied was "bating". Research work at the beginning of this century allowed this unpleasant "bate" to be replaced effectively by pancreatic enzymes, offered to the leather in a mix of ammonium chloride and wood flour. Commercial bating materials are now highly developed and highly specific. Some are now developed from bacterial sources. Considering the small amounts used and their specialist nature it is unlikely that there is a prospect for significant economic development in these products in the developing countries.

3.3.2 Bactericides

Bactericides are important in tanning to prevent bacterial actions damaging hides and skins prior to tannage and to avoid the growth of mould on stored wet blue. Common bactericides are salts of phenol, but as these can have a mild tanning not wanted at the early stages materials such as sodium pentachlorphenate, sodium hypochlorite or sodium trichlorite are used.

Bactericides have an enormity of uses and are normally available where there is a reasonable chemical industry infrastructure.

3.3.3 Synthetic tanning materials

Synthetic tanning materials is a term used to cover a great variety of substances. They were initially developed to replace vegetable tanning materials and reduce European dependence on overseas sources for the vegetable tanning materials. After their development it was found that they had a number of most useful properties related to light fastness, colour, dyeing assistance, leather feel and texture. They are increasingly important in their use in retannage and in various combination mixtures.

A large amount of products used in the leather industry is placed in the synthetic tanning materials category. The major groups involve treating phenols and naphthalenes with formaldehyde and sulphuric acid. Other materials, really aliphatic tans, are also included. These are aldehydes, acrylates, paraffin derivatives and some polycondensation products. Most of the materials are specially developed for the leather industry and in their tanning industry form have very limited use elsewhere.

3.3.4 Animal and vegetable oils and fats

Leathers which have only been tanned are not normally soft enough to use in the normal leather end uses. To provide the required level of softness, and also to improve other physical properties, oils and fats are added to the leather usually during the retannage stage. Initially vegetable and animal fats were used, and to these have been added synthetic materials and paraffin waxes.

Only rarely are these materials now applied to leather in the raw state. The transformation of oils for use in tanning is a specialist industry. Chemical treatment involved includes sulphation, sulphination, sulphiting, chlorination and condensation. Sulphated oils are those treated with sulphuric acid at low temperatures. While oils and fats have very wide application, those made specifically for the leather industry only have limited uses in other industries.

3.3.5 Dyeing auxiliaries

Dyeing auxiliaries cover a variety of mostly proprietary materials used in conjunction with specific dyestuffs to give improved effects. These often relate to penetration and fixtures, assisting in developing shades with good levelness and lightfastness, or helping to develop the degree of colour. Some materials in this category border on being syntans, and others are closer to fats or deliming agents. Fixing agents for suede, waterproofing agents and some wetting agents are included. Mostly these are highly specific proprietary products.

3.3.6 Dyes

Dyes have always been of major importance in the textile and leather industries and for many centuries they were obtained entirely from natural sources.

The prime purpose of most dyestuff manufacture is the dyeing of textiles and the classifications based on behaviour are to a large part derived from the type of textile which each class will dye. Thus, acid dyes will be suitable for wool and silk in an acid bath, basic dyes dye them directly and dye cotton with a mordant, and so on. Other important uses for dyestuffs are in photography, and all manner of stains and varnishes.

Most dyestuffs in use today contain an organic molecular structure called a "benzene ring" which has a light sensitive structure. By adjusting those organic structures complexes can be formed which are sensitive to light of certain colours. This results in a coloured appearance. The dyestuff industry today is very advanced, highly specialized, and dependent upon tar distillation or petrochemical products. As the leather trade has advanced and tried to enhance the natural qualities of leather so quality of dyeing has improved so that less "painted" finishes can be applied. Tanners mostly use anionic dyes, with a small amount of basic for certain colours. Solvent soluble dyes are used in finishing.

3.3.7 Leather finishes

The finishing of leather involves the application of a variety of surface coatings. Their purpose is to give protection to the surface, to beautify the leather, and to adjust the colour.

Leather finishes were initially based on casein, but more important today are resin finishes. These are mostly acrylic resins, to which are added pigments and auxiliary materials to give the right type of feel. The final surface protection is normally given with a coating of a nitrocellulose lacquer. Polyurethane materials have been used for some years to make patent leather finishes and they have recently been successfully introduced into regular finishes because of the excellent physical properties they add to the leather. Solvents used in finishing include ethyl alcohol, acetone, butyl acetate, methyl acetate and ethyl glycol amongst others. Other than solvents, most leather finishes are prepared especially and exclusively for the leather industry.

4. REQUIREMENTS FOR TANNING CHEMICALS, 1980-2000

Requirements for tanning chemicals and other materials has been assessed using the rates shown in annex 1, table A2. The rates are expressed in terms of kg per 100 kg of raw hides or shaved weight. The nineteen chemicals and materials have been divided in to three groups: General Purpose Chemicals; Basic Tanning Materials; and Performance Chemicals. Syntans and vegetable tans are often combined in the re-tannage of light leather with the actual quantity of each being used depending on the type of leather being made, the degree of filling required, the light fastness needed and other properties. Consequently an estimate has been made that the use of each will be equivalent overall. The rates shown in annex 1, table A2 have been applied to the raw hide estimates shown in table A4. The full results for the nineteen materials are shown in tables A5 to A23.

Tanners often have a choice of chemicals to use. Figures shown as requirements in this report refer to the total quantity necessary to process hides and skins in the most commonly used tannage. Actual quanitities of chemicals used are, of course, impossible to assess because of the variety of chemicals and methods applied. Furthermore, some countries have made a clear division between leather for home consumption and that for export. This dichotomy adds difficulty to assessing the market demand for chemicals since leather produced for local consumption in many developing countries is rarely, if ever, subjected to the same level of chemical treatment as that intended for export.

The information contained in the nineteen tables (A5-A23) is summarized in table 4.1. The total world demand for tanning chemicals in 1980 was about 4.5 million tons, and this is expected to increase to almost 6 million tons by the year 2000 - an increase of one-third over 1980. (The total amount of different chemicals is, of course, a rather meaningless aggregate. It is used here only to indicate the expected relative increase in all tanning chemicals, assuring that the mix of chemicals in the aggregates remain approximately the same.)

Table 4.1. Estimated world requirements for chemical and other tanning materials for leather production, 1980 to 2000

(thousand tons per year)

Chemicals/materials	Annex 1 Table for details	1980	1990	2000
General purpose chemicals				
Sodium sulphide	A5	222	256	290
Calcium hydroxide	A6	333	383	435
Hydrochloric acid (con)	A7	22	26	29
Ammonium sulphate	A8	148	170	193
Sodium bisulphite	A9	111	128	145
Sodium chloride	A10	1,108	1,278	1,449
Calcium formate	A11	129	152	175
Sulphuric acid (con) 96%	A12	296	341	386
Sodium carbonate	A13	129	152	175
Sodium sulphite	A14	129	152	175
Basic tanning materials				
Chrome salts	A15	646	760	876
Vegetable tanning materials	A16	305	338	371
Performance chemicals				
Bates	A17	59	68	77
Bactericides	A18	22	26	29
Syntans	A19	194	228	263
Fat liquors	A20	259	304	350
Dyeing auxiliaries	A21	172	202	233
Dyes	A22	27	32	37
Finishes	A23	194	229	264
Total requirements		4,505	5,225	5,952

Source: See annex.

5. POSSIBILITIES FOR INCREASING PRODUCTION OF TANNING CHEMICALS IN DEVELOPING COUNTRIES

Whereas bulk chemicals and petrochemicals are produced in large scale in an increasing number of developing countries, special chemicals are still very difficult to produce in the majority of these countries. Of the 19 chemicals selected in this study, all general purpose chemicals (10 in number) are and could be produced for industrial purposes and agriculture in a large number of developing countries and thus their utilization in the leather industry would present no major difficulty. Limited demand of these chemicals from the leather industry would be compensated by demand from other industrial sectors and total demand would render the establishment of world-scale plants viable in these countries.

Many basic materials are products of the petrochemical or steel industry. Nearly forty developing countries are producers in these industries. The present trend in industrial restructuring indicates furthermore that a continuous shift in locating these industries near the hydrocarbon and energy resources in developing countries. There the potential for producing these chemicals in the developing countries becomes more attractive.

It should be stated that the application of some of the chemicals used in the leather industry is "more art than science". In these cases which mostly affect high value speciality chemicals mainly used in the dyeing and finishing stages, it would be difficult for developing countries to undertake their production. They would mainly be obtained through imports and may in some cases be established on the basis of special arrangements - with their licensors.

It should be stressed that before considering the establishment of production facilities of tanning chemicals some determining factors should be closely examined which include:

commodity determinants - technical
- economic

country determinants - infrastructure
- logistics
- government policies

5.1 Commodity determinants - technical/economic

The major technical constraints are concerned with the processes of production, quality and process control, and raw material availablility. Leather can be produced easily without the use of very sophisticated equipment. But, benefits are sometimes reduced by the need to import part of the inputs needed for its production.

Developing countries attempting to produce leather for export are meeting technical difficulties connected with quality and process controls. Firms within the European chemical industry express concern regarding "process control" since lack of good quality control during early stages of manufacture can have adverse effects on later processes. It seems clear that even if the effects of a lack of quality control have been overstressed, the exercise of proper control is important and does present problems for countries which lack sufficiently well trained personnel.

The manufacturing of many chemicals is characterized by large scale and the efficient utilization of by-products and the continuous development of the quality of products depend on successful research which is the product of the knowledge of advanced technical know-how and the presence of well-trained and experienced research personnel. Countries with a potentially massive outlet for home consumption (such as Argentina, India and the Republic of Korea) are, obviously, in a better position to be successful than other developing countries whose internal levels of demand are low and who lack resources. Licensing agreements or some other form of acquired knowledge of existing processes would help the establishment of these industries in these developing countries.

Many chemical enterprises also depend on a local supply of raw chemical materials to be commercially successful. Many basic materials are the by-products of petrochemical or steel industries. Thus, countries possessing these two industries have a distinct advantage over those who do not. It is considered that by 1990, chemicals, generally, will be produced nearer to petroleum sources than they are now. Of course, third generation fractions of hydrocarbon resources can be imported to facilitate the production of fine chemicals. But the constraining factors of technology (i.e. process know-how) and market size remain.

A major constraint preventing the successful launching of some new chemical industries is the size of plants required for operations to be commercially viable. Chromium-based industry is a typical example where the plant sizes required are for:

- Chrome sulphate: 4,000 tons annual capacity
- Sodium dichromate: 50,000 tons per annum.

In contrast, Africa, as a whole, presently uses only 10,000 tons of chromium oxide annually which translates to approximately 40,000 tons of chrome sulphate. For the successful establishment of such plants in developing countries where chromium deposits are mainly located it would be necessary to look outward for export markets. However, the current world production capacity for chrome chemicals, mostly in the developed countries, is in excess of demand.

It should be kept in mind that the production of chemicals is in principle capital-intensive, requiring considerable investments. The necessary scale of production adds to the capital cost of factory establishment. The more sophisticated processes that are used in the production of some chemicals add to overall costs. A spray-drier, for example, can exceed a cost of $3 million, and many purchasers of chrome chemicals demand that the product is in dry-sprayed form.[3/] Dry spraying is also moving into a high technology area of production.

3/ The economic size of a dry-sprayed powder unit is 2,500 tonnes.

But the economic scale requirements are not prohibitive for small countries and small markets in the case of many basic chemicals such as sulphuric acid and vegetable tanning extracts. Niches in the markets may also be found where highly specialized production of certain chemicals can be economical even on a small scale. In other instances, monopolistic profit levels of the existing producers and/or their distribution costs may be so high that the cost disadvantage due to small scale may be compensated, and local production thus commercially feasible. However, the true opportunities would have to be investigated in each case individually. The only thing that can be said with general applicability is that the industry's technical/economic determinants do not categorically rule out economically viable production in the developing countries.

5.2 Country determinants: infrastructure and logistics

Poor communication systems do not encourage the marketing of rawstock. Contributing factors are poor roads (or lack of roads); poor intelligence services regarding marketing channels and prices (or lack of services) and poor farm extension services (farmers are very often not aware of the value of hides and skins or of the opportunities for marketing). Bad road conditions act as a deterrent to would-be entrepreneurs who might otherwise be enticed into marketing activities. The consequence of all these factors is an inadequate supply of hides and skins on which to base a viable tanning industry.[4/]

Poor communication systems can also influence international trade. Would-be purchasers of tanning chemicals in developing countries may find it is easier to arrange shipment and receive goods from developed countries suppliers than attempting to import from a neighbouring country.

4/ Six or almost a third of African countries surveyed by UNIDO consultants reported "shortage of raw hides and skins" as a constraint to industrialization of the leather tanning industry. The situation is also aggravated by the inefficient collecting systems for raw hides and skins (eight observations).

On these broad aspects of infrastructure, many developing countries face a major disadvantage compared to the developed country areas. The efficient production and marketing of chemicals not only requires adequate roads, organized trade routes and facilities, but also, ideally, raw materials and petrochemical and steel industries - all of these features are to be found in major producer countries in close proximity to each other and physically close to sea or land routes.

Some tanning chemicals are sensitive to temperature and need special storage and careful transportation. Liquid syntans, for example, are difficult to transport because of chemical reactions which occur if roads are in bad condition (the reaction has been described as similar to "turning milk into butter"). In this respect, landlocked countries are particularly disadvantaged if their neighbouring countries do not maintain an adequate through-road.

5.3 Country determinants: government policies

Local chemical industry is sometimes protected by tariffs and import taxes. At the same time, however, duties are often being charged on imports of chemicals that are essential to manufacture in the countries concerned but not on imported manufactured goods using these materials. This forces up local costs thus making it difficult for finished goods to be competitive in both domestic and export markets. Co-ordination of government policies is needed in order to expand the production and to create scope for the development of local products.

Tendering for tanning projects is sometimes very difficult. Tender documents frequently contain only a general chemical description because of the lack of precise knowledge. This lack of knowledge leads to ambiguity in drafting the terms of reference to the extent that the contract falls short of the terms of reference. Frequently, proposals are accepted considering cost only and this can lead to the acceptance of proposals which are inadequate with regard to other aspects, such as chemical-plant specification, transporting, handling, etc. The involvement from the very beginning of a knowledgeable and reliable consultant or partner would ensure the successful development of the plant from the beginning.

Finally, the lack of foreign currency may be of over-riding importance to governments attempting to formulate trade policy or create industry. Thus, the desire to create a local tanning chemical industry, either to provide leather for export or support local leather goods manufacture, will be motivated strongly by the desire to obtain foreign currency.

6. TANNING CHEMICAL MANUFACTURE - ALTERNATIVE TECHNOLOGY OR SUBSTITUTION

6.1 Increasing preferences for a natural look in leather

Some developing countries already have a chemical industry, albeit small by comparison to those which exist in the developed countries, and some tanning chemicals are being manufactured. In some cases these industries are established in collaboration with long established companies in Europe, North America and elsewhere. Hence, some of the technical constraints to development of chemical industries mentioned in the previous section have been overcome.

Modern techniques of chemical production based on the existence of petrochemical and steel industries are a comparatively recent innovation. It is not so long ago that tanners were making leather of good quality, with high wearing properties in many diverse end uses with totally indigenous raw materials. A return to this situation could in some instances be feasible if the proper levels of skill and technology were to be present or could again be acquired. But, for large tanning units dedicated to the export of semi-processed or finished leather to developed world end users, the reversion to the flexible, craft approach would not the commercially feasible. Such units are capital intensive and would lose their economic viability if their processing lost its efficiency. However, in countries where the tanning industry is still in its infancy, or where it is based in small, less merchanized units, the idea of an alternative technology has greater validity. If one takes a lead from Italy, which had outstanding success in strengthening its tanning industry in the 1970s against international trends, the objective can be set to achieve a higher value added by producing a higher quality hand crafted product, specialized production, and improved industrial engineering.

Although the Italians have some of the best equipped and most efficient tanneries in the world, their marketing skill has relied on the technical merits of the leather they produce and its truly natural appearance. Many other countries, trying to emulate the Italians during this period became frustrated by the fact that Italian leather and shoes continued to gain

strength despite the poorer specification of their leather. Very often this poor specification came as the result of the continued use of traditional materials to retain the natural quality of the product rather than improving the physical properties of low grade leather. A typical example would be the use of protein finishes which has continued in Italy while much of the rest of the world is totally dependent on acrylic and polyurethane resins, with a hefty topping of nitro-cellulose lacquers. Much of the Italian success also stems from a very effective organization (industrial engineering) of its leather products industry into highly specialized, but synchronized units.

The consumer in the developed world has shown preference for the more natural material. This is a trend which might be expected to develop further towards the end of the century. With raw material supply falling behind the demand for leather, the price per unit of leather since 1973 has steadily increased. OECD consumers are looking for leather of high quality, which in their view means of good appearance, good colour, good feel and emphasizing the fact that it maintains the strengths of a truly natural material. As a consequence leather tanned and prepared with a high proportion of indigenous natural materials could well gain advantage in the market place if carefully marketed.

6.2 Alternative technology possibilities

Where do the opportunities lie for the exploitation of this situation? Primarily, they are in the utilization of local vegetable extracts.[5/] A great number of plants and trees contain tannin, and there are some such as mimosa which can be specially planted for this purpose and be available for harvesting in less than ten years. The advances in vegetable tanning in recent years give considerably improved opportunities for leather made in this way. The technology for producing extracts is not complex, the scale of the operations not necessarily large, and in some instances, the production can be carried out by the tannery itself.

5/ However, the amount of energy required to produce vegetable tanning materials in powder form is large and may, therefore, constitute a considerable constraint in some countries.

Soya bean, coconut, palm oil, fish oils and many others which are produced in most developing countries can be satisfactorily prepared for tannery use. Tanners use mixtures of natural, sulphated, and sulphited oils. Sulphating is relatively straightforward and can be established as long as their minimum local consumption is guaranteed. Sulphiting is much harder to introduce but is the smaller proportion of the material used. Other specialized oils would have to be imported. Work has recently been carried out at the National Research Centre in Cairo, Egypt, where locally available sardine oil and neatsfoot oil have been processed for use as tanning oils. Thus, a carefully balanced national or regional programme based primarily on indigenous vegetable extracts, fats and oils but supplemented by smaller amounts of imported inputs would appear a worthwile proposition in many instances. The importance of co-ordinated government policies, however, must be emphasized here.

Indigenous, natural dyes and pigments are often available, but great care would have to be taken in their use, as the importance of good colour and proper colour fastness cannot be over-emphasized when a high-priced and high quality product is an objective.

The availability of chrome tanning materials depends first upon the existence of local ores, and secondly on the quality of that ore. High purity ores are essential for producing chrome tanning powders. Ores with high iron content give rise to problems. Currently, the operation of chrome powder plants is large scale, intended to serve a comparatively large scale tanning industry. A study would be required to determine whether a small scale units could be made economically feasible.

6.3 Possibility for substitutions

There is little scope for alternative technology application in relation to general chemicals, but there is considerable possibility for substitutions. The most important chemicals in this respect are lime, salt and sodium sulphide.

Lime free systems of beamhouse processing do exist but have not been perfected. However, since lime is readily available in many parts of the world it provides an obvious opportunity for most developing countries.

Although the use of common salt in preserving hides can be minimized and eliminated, it plays an important role in the pickling process. As with lime, salt is widely available in either marine or rock form and intra-regional trade should allow it to be available to tanneries in all countries.

Sodium sulphide is a sharpening agent. It is chemically produced, usually in large-sized manufacturing plants. Considering its low unit cost and its value in terms of speed and efficiency of manufacture, its use will probably continue in the future. Regional co-operation in its manufacture might be considered a possibility. However, many attempts are presently under way to replace it by other materials, because of undesirable environmental impacts.

For deliming the tanner has a wide choice, viz:

Hydrochloric acid	Lactic acid
Acetic acid	Formic acid
Boric acid	Sodium bisulphite
Ammonium chloride	Ammonium Sulphate

Local or regional supplies of nitrogenous fertilizers including ammonium sulphate are increasing rapidly in the developing countries. Moreover, the strategy to manufacture fertilizers, perhaps in mini-plants would make the production of fertilizers viable in a large number of developing countries.[6/] This ought to make it possible to obtain suitable deliming materials without the need for imports from OECD countries.

For basification of chrome tanning materials sodium carbonate and sodium bicarbonate are used. Recently calcium carbonate materials (chalk) have become more popular though their use in tanning is associated with certain risks of damage to the grain of the leather. Chalk is often available

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6/ Mini-fertilizer plant projects, UNIDO/IS.416 and Add.1, December 1983.

naturally, while development of sodium carbonate and bicarbonate is most likely in the developing world given their important uses outside the leather industry.

Neutralization of leather, like deliming, also gives the tanner many options, viz:

Sodium bicarbonate	Sodium sulphite
Ammonium bicarbonate	Sodium formate
Calcium formate	Borax

Thus, as with deliming agents, the manufacture of one or more of these materials should be feasible, given their important non-leather uses even if tanning itself is unable to offer an economic demand.

In certain instances where the local market is limited or no raw material is locally available and/or in the presence of other constraints regional co-operation for the production of these leather chemical presents an excellent opportunity and vehicle for the development of their manufacture and trade.

7. STRATEGIES FOR DEVELOPMENT

7.1 Requirements and feasible alternatives

Most of the determining factors discussed in section 5 are well known to those engaged in the chemical industry and to those who in developing countries are responsible for the construction and development of local enterprises. It is, of course, necessary for all concerned to co-operate to alleviate, or even to eradicate, the pressures which constraints cause, and to seize the opportunities that exist. In most instances, all that is required is a better understanding of the problems involved and a real desire to resolve them. There are two fundamental issues of a technical nature that need to be resolved for the successful manufacture of tanning chemicals. These are:

- the availablility of petrochemical or steel industries, to provide the basic material for syntans and organic chemicals;
- a large home market and/or large-scale export market to sustain production from large-scale modern chemical industrial complexes.

However, developing countries attempting to establish chemical industries will be faced with the same problems of economies of scale as well-established chemical companies in the more developed world. They may also be faced with the problems of multi-product formulations if they attempt to produce chemicals through modern techniques. Developing countries having petrochemical and/or large-scale steel industries could contemplate the establishment of tanning chemical plants.

Some, but not many, types of chemicals could be produced using "alternative technology", i.e. techniques used to produce chemicals not envolving modern processes. But it may be possible to increase the scope of using domestically produced materials by substituting modern chemicals for materials previously used in the tanning industry. Table 7.1 shows the most constraining factors facing developing country production through the use of modern technology and those chemicals which may be produced using alternative

technology or by substitution. In general, alternative technology opportunities are confined to the basic tanning materials and performance chemicals, but it should be possible to substitute for a number of general purpose chemicals.

Some developing countries possess petrochemical industries and manufacture a wide range of chemicals including some required by the tanning industry. Likewise, some developing countries possess raw materials of interest to a chemical industry but do not possess the technical means or scale of market to exploit their potential. However, this could be remedied through North-South or South-South co-operation.

Some developing market economies (either at government level or through private enterprise) are already co-operating with chemical industrial companies from more developed economies in order to produce and utilize chemicals (North-South co-operation). Such co-operation could be considerably increased if the constraints discussed in section 5 could be, at least, mitigated. The emphasis of chemical production through North-South co-operation must be focused on the production of chemicals in general and not only on those required for tanning. Some of the reasons for this are concerned with economies of plant operation and the wide range of chemicals and chemical products which are automatically derived through the flow-line techniques of modern chemical production.

All the above considerations lead to the conclusion that co-operation between developing countries, particularly on a sub-regional basis, (South-South co-operation) might be feasible if a suitable physical basis exists.

7.2 Modalities for co-operation

The developing countries show wide variation in the levels of development attained and wide diversification in the nature of development. The differences between countries within a group will determine the nature and extent of feasible co-operation. Therefore, co-operating groups in a

Table 7.1. Developing market economies, facets of tanning chemical production

	Chemical/material	Most constraining factor facing developing country production (modern technology)	Alternative technology (AT) or substitution possible (S)	Major producers amongst developing countries; 1980 production, thousand tons, in parenthesis (information only available for chemicals against which figures are entered)
General purpose chemicals				
1	Sodium sulphide	Large scale industry required	Not readily	
2	Calcium hydroxide	Local materials needed	No	
3	Hydrochloric acid	Chemical industry needed	(S)	
4	Ammonium sulphate	Large scale industry required	(S)	Brazil (444), Cuba (166), Rep. Korea (1,031), Mexico (1,883), Venezuela (350)
5	Sodium bisulphite	Chemical industry needed	(S)	
6	Sodium chloride	Local materials needed	No	
7	Calcium formate	Chemical industry needed	(S)	
8	Sulphuric acid	Large scale industry required	(S)	Brazil (2,408), India (2,217), Rep. Korea (1,683), Mexico (2,359), Morocco (806), Tunisia (1,634)
9	Sodium carbonate	Large scale industry required	(S)	
10	Sodium sulphite	Large scale industry required	(S)	
Basic tanning materials				
11	Chrome salts	Supply of good quality chrome very restricted	(AT)	Argentina (95), Paraguay (16)
12	Veg tan materials	No major factors	(AT)	Argentina (95), Paraguay (16)
Performance chemicals				
13	Bates	See text		
14	Bactericides	See text		
15	Syntans	Petrochemical industries required	(AT)	
16	Fatliquors	None	(AT)	Mexico (190), Chile (3.7), Pakistan (1.1), Venezuela (38)
17	Dyeing auxiliaries	Acquiring art of production	No	
18	Dyes	Acquiring art of production	(AT)	India (20), Mexico (4.7), Rep. Korea (4.5)
19	Finishes	Petrochemical, steel industries required	(AT)	

South-South dialogue are unlikely to be composed of similar type economies, particularly in relation to chemical production. Table 7.2 provides a classification for developing countries based on attributes relevant to chemical production.

Table 7.2. Classification of developing countries in relation to aspects of chemical production

Description	Classification code
Economies with a relatively major chemical industry; advanced economies in the group usually with large domestic markets and above average resources. Tanning and leather manufacturing industries likely to be comparatively advanced.	A
Economies with minor chemical industry; some chemical raw material reserves partially exploited. The domestic markets vary from medium to small.	B
Economies with no, or very small chemical industry but with unexploited chemical raw material reserves. The domestic markets vary from small to medium.	C
Economies with no chemical industry and no known chemical raw material resources. Likely to have small markets with relatively poor industrial base.	D

It is possible to conceive that a regional group may be composed of countries from only one or any combination of the classification types. It is also possible to conceive economies which do not fit exactly into one of the four types defined but, for purposes of simplicity, strategies for development will be considered for groupings involving only the four defined types.

It is considered that for co-operation to be successful two conditions must be satisfied:

(i) all countries in a co-operating group must obtain benefits from the co-operation;

(ii) co-operation must embrace not only chemical production but also the provision of hides and skins, tanning and production and trade for leather and leather goods.

Therefore, strategies for co-operation are presented below based on the following elements:

Chemical industry	- supply of raw materials from co-operating countries - assistance to develop chemical industries, or - assistance to develop a restricted chemical industry geared to tanning requirements
Hides and skins	- trade in hides and skins
Tanning industry	- assistance to develop tanning industry using group chemicals/materials - supply of chemicals from economies within group
Trade in leather and leather goods	- trade free from tariffs and import taxes for leather and leather products - convertible currencies.

Tables 7.3 to 7.5 summarize the strategies of co-operation considering only the simplest country combinations, i.e. when only two of the classified types are involved. Strategies for more diverse co-operating groups can be deduced easily from the tables.

Table 7.3. Strategies for South-South co-operation to develop tanning chemical production: country groups A and B, A and C, A and D

Type of co-operation	Co-operation possible between developing countries in co-operative group A and B	A and C	A and D
Chemical industry			
1 Supply of raw materials	yes, both ways	yes, both ways	yes, A to D
2 Assistance to develop chemical industries	yes, A to B	yes, A to C	n.a.
3 Assistance to develop restricted chemical industry geared to tanning requirements	n.a.	n.a.	yes, A to D
Hides and skins			
1 Trade in hides and skins	yes, B to A	yes, C to A	yes, D to A
Tanning industry			
1 Assistance to develop tanning industry using group chemicals	yes, A to B	yes, A to C	yes, A to D
2 Supply of chemicals	yes, both ways	yes, both ways	yes, A to D
Leather and leather goods			
1 Assistance to develop leather and leather goods production	yes, A to B	yes, A to C	yes, A to D
Trade in leather and leather products			
1 No tariffs for leather and leather products	yes, both ways	yes, both ways	yes, both ways
2 Convertibility of currencies	yes, both ways	yes, both ways	yes, both ways

Notes: n.a. = not applicable; see table 7.2 for country group classifications.

Table 7.4. Strategies for South-South co-operation to develop tanning chemical production: country groups B and C, B and D, C and D

Type of co-operation	Co-operation possible between developing countries in co-operative group B and C	B and D	C and D
Chemical industry			
1 Supply of raw materials	yes, both ways	yes, B to D	yes, C to D
2 Assistance to develop chemical industries	B to C TA both B and C	n.a. TA by B	n.a. TA by C
3 Assistance to develop restricted chemical industry geared to tanning requirements	n.a.	yes, B to D TA by B	no TA by C
Hides and skins			
1 Trade in hides and skins	may be possible	may be possible	may be possible
Tanning industry			
1 Assistance to develop tanning industry using group chemicals	yes, both ways TA both B and C	yes, both ways TA both B and D	yes, both ways TA both C and D
2 Supply of chemicals	yes, both ways	yes, B to D	yes, C to D
Leather and leather goods			
1 Assistance to develop leather and leather goods production	yes, both ways TA both B and C	yes, both ways TA both B and D	yes, both ways TA both C and D
Trade in leather and leather products			
1 No tariffs for leather and leather products	yes, both ways	yes, both ways	yes, both ways
2 Convertibility of currencies	yes, both ways	yes, both ways	yes, both ways

Notes: n.a. = not applicable;
TA = technical assistance; by either developed countries or by country from indicated country grouping.
See table 7.2 for country group classifications.

Table 7.5, Strategies for South-South co-operation to develop tanning chemical production: country groups B only, C only, D only

Type of co-operation	Co-operation possible between developing countries in co-operative group B only	C only	D only
Chemical industry			
1 Supply of raw materials	yes, both ways	yes, both ways	n.a.
2 Assistance to develop chemical industries	no TA all	no TA all	n.a.
3 Assistance to develop restricted chemical industry geared to tanning requirements	n.a.	no TA all[a/]	no TA all
Hides and skins			
1 Trade in hides and skins	may be possible	may be possible	may be possible
Tanning industry			
1 Assistance to develop tanning industry using group chemicals	yes, all TA all	yes, all TA all	yes, all TA all
2 Supply of chemicals	yes, all	yes, all	n.a.
Leather and leather goods			
1 Assistance to develop leather and leather goods production	yes, all TA all	yes, all TA all	yes, all TA all
Trade in leather and leather products			
1 No tariffs for leather and leather products	yes, all	yes, all	yes, all
2 Convertibility of currencies	yes, all	yes, all	yes, all

Notes: n.a. = not applicable;
TA = technical assistance; by either developed countries or by country from indicated country grouping.
See table 7.2 for country group classifications.

a/ Only applicable if wider based chemical industries not possible.

It can be deduced from these tables that the strategies outlined have the following attributes:

- all countries would benefit from co-operation;

- technical assistance from the developed countries is not likely to be required for co-operating groups which contain an "A" economy (i.e. an economy already possessing a comparatively major chemical industry);

- if there is no "A" economy in a co-operating group, then considerable technical assistance is likely to be necessary;

- co-operating groups will benefit less and less as economies involved become of lesser order. For example, a combination where all economies are classified as "D" would, with regards to the chemical industry, be restricted to the possibility of manufacturing some tanning chemicals only.

Although it is possible to conceive developing countries which might co-operate successfully as a group, the details of co-operation and the assessment of benefits to be derived, etc. will require considerable investigation. The kind of enquiries needing to be made will depend, to some extent, on the nature of the economy under investigation. This paper concludes by using the above classification of economies to provide an outline of requirements for strategic studies.

The studies presuppose the identification of the economies being considered into one of the four classifications shown in table 7.2. The study outlines are provided in table 7.6. The major divisions of the studies, for which outlines are provided, are:

(i) Assessment of current situation
(ii) Constraints to expansion of chemical and leather industries
(iii) Forecast of supply and demand to 2000 (for chemicals and leather).

After individual country studies are completed, it will be necessary to rationalize the situations existing within and between countries with a view to the promotion of

- chemical industries in all countries (where this is feasible);
- utilization of chemical resources from within the co-operating group of countries;
- manufacture of leather and leather products within the co-operating group of countries;
- minimization (if not elimination) of trade barriers and currency convertibility between the co-operating countries for products required to make a regional co-operation plan successful.

Finally, an economic feasibility assessment will need to be provided for the overall plan arising from the rationalization of country situations.

Table 7.6. Country strategic study outlines

Outline	Classification of country A	B	C	D
Assessment of current situation				
1 Country financial and economic appraisal	yes	yes	yes	yes
2 Local availability of raw materials for chemical industry	yes	yes	yes	no
3 Local availability of hides and skins	yes	yes	yes	yes
4 Chemical production and utilization, with special reference to the tanning industry	yes	yes	no	no
5 Tanning industry and leather manufacture	yes	yes	yes	yes[a/]
6 Imports of raw materials and finished chemicals for chemicals industry	yes	yes	yes	no
7 Imports of finished chemicals and their utilization	no	no	no	yes
8 Scope of markets (domestic and export) for chemicals	yes	yes	yes	no
9 Scope of markets (domestic and export) for leather and leather goods	yes	yes	yes	yes[a/]
10 Balance sheets of supply and demand				
(a) Chemicals with special reference to tanning chemicals	yes	yes	yes	yes
(b) hides and skins	yes	yes	yes	yes
(c) leather	yes	yes	yes	yes
(d) leather shoes and goods	yes	yes	yes	yes
Constraints to expansion of chemical and leather industries [a/]				
1 Topics to be considered to include:				
(a) lack of physical resources				
(b) lack of capital resources (including foreign exchange)				
(c) lack of infrastructure				
(d) lack of technical knowledge				
(d) lack of trained manpower				
(e) social customs				
Forecasts of supply and demand to 2000				
1 Chemicals, with special reference to tanning chemicals	yes	yes	yes	yes
2 Leather, including potential supply from domestic resources	yes	yes	yes	yes

a/ In appropriate cases only.

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Table A1. Production of leather 1980, 1990 and 2000

	Heavy bovine leather 1000 mt	Light leather bovine	sheep & goats	total
		million sq.ft		
1980				
Developed market economies	143.2	3,078	1,262	4,340
CPE Europe (incl. USSR)	162.1	1,470	423	1,893
Developing market economies	161.4	2,884	1,164	4,048
Sub-Saharan Africa	1.8	110	108	218
North Africa and West Asia	22.8	255	294	549
South Asia	57.3	873	564	1,437
South-East Asia	17.9	297	21	318
Latin America	61.6	1,349	176	1,525
CPE Asia	37.4	430	184	614
World	504.3	7,862	3,033	10,895
1990				
Developed market economies	130.0	3,372	1,200	4,572
CPE Europe (incl. USSR)	140.0	1,745	450	2,195
Developing market economies	190.0	3,651	1,464	5,115
Sub-Saharan Africa	2.4	150	120	270
North Africa and West Asia	26.4	415	400	815
South Asia	71.5	1,059	738	1,797
South-East Asia	23.5	357	22	379
Latin America	66.2	1,670	184	1,854
CPE Asia	40.0	522	206	728
World	500.0	9,290	3,320	12,610
2000				
Developed market economies	123.0	3,653	1,160	4,813
CPE Europe (incl. USSR)	105.0	2,020	480	2,500
Developing market economies	216.0	4,435	1,900	6,335
Sub-Saharan Africa	3.0	200	230	430
North Africa and West Asia	30.0	578	520	1,098
South Asia	85.0	1,247	926	2,173
Southeast Asia	28.0	416	28	444
Latin America	70.0	1,994	195	2,189
CPE Asia	46.0	614	214	828
World	490.0	10,721	3,754	14,475

Source: The leather and leather products industry: Trends, prospects and strategies for development, UNIDO/IS.442, February 1984.

Table A2. Chemicals and tanning materials for leather production per unit of hide; factors used in deriving total requirements [a/]

Chemicals/materials		Heavy leather	Light leather raw hides
		kg per 100 kg	
General purpose chemicals			
Sodium sulphide	Na_2S	3.0	3.0
Calcium hydroxide	$Ca(OH)_2$	4.5	4.5
Hydrochloric acid (con)	HCl	0.3	0.3
Ammonium sulphate	$(NH_4)_2(SO_4)$	2.0	2.0
Sodium bisulphite	$NaHSO_3$	1.5	1.5
Sodium chloride	NaCl	15.0	15.0
Calcium formate	$Ca(COOH)_2$		2.0
Sulphuric acid (con) 96%	H_2SO_4	4.0	4.0
Sodium carbonate	Na_2CO_3		2.0
Sodium sulphite	Na_2SO_3		2.0
Basic Tanning materials			
Chrome salts	$Cr_2(SO_4)_3$		10.0
Vegetable tanning materials [b/]	12.0	3.0	
Performance chemicals			
Bates		0.8	0.8
Bactericides		0.3	0.3
Syntans [b/]			3.0
Fat liquors			4.0
		kg per 100 kg shaved weight	
Dyeing auxiliaries			3.8
Dyes			0.6
Finishes			4.0

a/ Due to a variety of recepies and change in fashions, colours, etc., the actual amounts of chemicals and tanning materials per unit of hide vary within rather wide ranges; the unit values given in the table should be considered illustrative only.

b/ It has been assumed that on aggregate for all light leathers the use of vegetable tanning materials will equal the use of syntans. Hence the use of 6 kg of each material needed per 100 kg raw hides has been shown as 3 kg per 100 kg raw hides for each of the two materials.

Table A3. Conversion factors used in calculation of chemicals/material requirements for tanning

Type of hide or skin	Raw weight	Shaved weight	Leather
Heavy bovine	1 ton	0.4 tons	0.543 tons
Light bovine	1 ton	0.7 tons	1,700 sq.ft
Light sheep/goat	1 ton	0.7 tons	2,700 sq.ft

Source: Informal Meeting of Experts on Improvement of Commodity Intelligence and Statistics for Hides, Skins and Leather, Rome 7-9 July, 1975. Common Denominations and Conversion Factors for Hides and Skins and their Derived Products, FAO, ESCR:Hs 75/2, Rome, 1975.

Table A4. Raw hide necessary for leather production 1980, 1990 and 2000

(thousand tons. Leather production as in table A1)

	Heavy leather	Light leather
1980		
Developed market economies	264	2,539
CPE Europe (incl. USSR)	298	1,188
Developing market economies	297	2,381
Sub-Saharan Africa	3	100
North Africa and West Asia	42	240
South Asia	106	752
South-East Asia	33	229
Latin America	113	1,057
CPE Asia	69	354
World	928	6,465
1990		
Developed market economies	238	2,757
CPE Europe (incl. USSR)	259	1,401
Developing market economies	350	3,011
Sub-Saharan Africa	4	133
North Africa and West Asia	49	378
South Asia	132	920
South-East Asia	43	276
Latin America	122	1,304
CPE Asia	74	430
World	920	7,599
2000		
Developed market economies	226	2,966
CPE Europe (incl. USSR)	193	1,615
Developing market economies	397	3,675
Sub-Saharan Africa	6	188
North Africa and West Asia	55	520
South Asia	150	1,093
South-East Asia	51	321
Latin America	129	1,553
CPE Asia	85	502
World	901	8,758

Source: The leather and leather products industry: Trends, prospects and strategies for development, UNIDO/IS.442, February 1984.

Table A5 : Sodium Sulphide Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies	7.9	76.2	84.1	7.2	82.7	89.9	6.8	89.0	95.8
CPE Europe (incl USSR)	8.9	35.6	44.5	7.7	42.1	49.8	5.8	48.4	54.2
Developing Market Economies	8.9	71.4	80.3	10.5	90.3	100.8	11.9	110.2	122.1
Sub-Saharan Africa	0.1	3.0	3.1	0.1	4.0	4.1	0.2	5.6	5.8
North Africa and West Asia	1.2	7.2	8.4	1.5	11.3	12.8	1.6	15.6	17.2
South Asia	3.2	22.6	25.8	4.0	27.6	31.6	4.7	32.8	37.5
South East Asia	1.0	6.9	7.9	1.3	8.3	9.6	1.5	9.6	11.1
Latin America	3.4	31.7	35.1	3.6	39.1	42.7	3.9	46.6	50.5
CPE Asia	2.1	10.7	12.8	2.2	12.9	15.1	2.5	15.1	17.6
WORLD	27.8	193.9	221.7	27.6	228.0	255.6	27.0	262.7	289.7

Table A6 : Calcium Hydroxide Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies	11.9	114.3	126.2	10.7	124.1	134.8	10.1	133.5	143.6
CPE Europe (incl USSR)	13.4	53.4	66.8	11.6	63.0	74.6	8.7	72.7	81.4
Developing Market Economies	13.4	107.0	120.4	15.8	135.5	151.3	17.9	165.4	183.3
Sub-Saharan Africa	0.1	4.5	4.6	0.2	6.0	6.2	0.3	8.5	8.8
North Africa and West Asia	1.9	10.8	12.7	2.2	17.0	19.2	2.5	23.4	25.9
South Asia	4.8	33.8	38.6	5.9	41.4	47.3	7.0	49.2	56.2
South East Asia	1.5	10.3	11.8	2.0	12.4	14.4	2.3	14.4	16.7
Latin America	5.1	47.6	52.7	5.5	58.7	64.2	5.8	69.9	75.7
CPE Asia	3.1	16.1	19.2	3.3	19.4	22.7	3.8	22.5	26.3
WORLD	41.8	290.8	332.6	41.4	342.0	383.4	40.5	394.1	434.6

Table A7 : Hydrochloric Acid (con) Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies	0.8	7.6	8.4	0.7	8.3	9.0	0.7	8.9	9.6
CPE Europe (incl USSR)	0.9	3.6	4.5	0.8	4.2	5.0	0.6	4.8	5.4
Developing Market Economies	0.9	7.1	8.0	1.1	9.0	10.1	1.2	11.0	12.2
Sub-Saharan Africa	...	0.3	0.3	...	0.4	0.4	...	0.5	0.5
North Africa and West Asia	0.1	0.7	0.8	0.2	1.1	1.3	0.2	1.5	1.7
South Asia	0.3	2.2	2.5	0.4	2.8	3.2	0.5	3.3	3.8
South East Asia	0.1	0.7	0.8	0.1	0.8	0.9	0.1	1.0	1.1
Latin America	0.4	3.2	3.6	0.4	3.9	4.3	0.4	4.7	5.1
CPE Asia	0.2	1.1	1.3	0.2	1.3	1.5	0.2	1.6	1.8
WORLD	2.8	19.4	22.2	2.8	22.8	25.6	2.7	26.3	29.0

... indicates a value of less than 50 tons

Table A8 : Ammonium Sulphate Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies	5.3	50.8	56.1	4.8	55.1	59.9	4.5	59.3	63.8
CPE Europe (incl USSR)	6.0	23.8	29.8	5.1	28.0	33.1	3.9	32.3	36.2
Developing Market Economies	5.9	47.5	53.4	7.0	60.3	67.3	7.9	73.5	81.4
Sub-Saharan Africa	0.1	2.0	2.1	0.1	2.7	2.8	0.1	3.8	3.9
North Africa and West Asia	0.8	4.8	5.6	1.0	7.6	8.6	1.1	10.4	11.5
South Asia	2.1	15.0	17.1	2.6	18.4	21.0	3.1	21.9	25.0
South East Asia	0.7	4.6	5.3	0.9	5.5	6.4	1.0	6.4	7.4
Latin America	2.2	21.1	23.3	2.4	26.1	28.5	2.6	31.0	33.6
CPE Asia	1.4	7.1	8.5	1.5	8.6	10.1	1.7	10.0	11.7
WORLD	18.6	129.2	147.8	18.4	152.0	170.4	18.0	175.1	193.1

Table A9 : Sodium Bisulphite Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies	3.9	38.1	42.0	3.6	41.4	45.0	3.4	44.5	47.9
CPE Europe (incl USSR)	4.5	17.8	22.3	3.9	21.0	24.9	2.9	24.2	27.1
Developing Market Economies	4.5	35.7	40.2	5.2	45.2	50.4	5.9	55.1	61.0
Sub-Saharan Africa	0.1	1.5	1.6	0.1	2.0	2.1	0.1	2.8	2.9
North Africa and West Asia	0.6	3.6	4.2	0.7	5.7	6.4	0.8	7.8	8.6
South Asia	1.6	11.3	12.9	2.0	13.8	15.8	2.3	16.4	18.7
South East Asia	0.5	3.4	3.9	0.6	4.1	4.7	0.8	4.8	5.6
Latin America	1.7	15.9	17.6	1.8	19.6	21.4	1.9	23.3	25.2
CPE Asia	1.0	5.3	6.3	1.1	6.4	7.5	1.3	7.6	8.9
WORLD	13.9	96.9	110.8	13.8	114.0	127.8	13.5	131.4	144.9

Table A10 : Sodium Chloride Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies	39.6	380.8	420.4	35.7	413.6	449.3	33.9	444.9	478.8
CPE Europe (incl USSR)	44.7	178.2	222.9	38.7	210.1	248.8	29.0	242.2	271.2
Developing Market Economies	44.6	356.7	401.3	52.5	451.6	504.1	59.5	551.3	610.8
Sub-Saharan Africa	0.4	15.0	15.4	0.6	19.9	20.5	0.9	28.2	29.1
North Africa and West Asia	6.3	36.0	42.3	7.4	56.7	64.1	8.2	78.0	86.2
South Asia	15.9	112.8	128.7	19.8	138.0	157.8	23.4	164.0	187.4
South East Asia	5.0	34.3	39.3	6.4	41.4	47.8	7.6	48.1	55.7
Latin America	17.0	158.6	175.6	18.3	195.6	213.9	19.4	233.0	252.4
CPE Asia	10.3	53.6	63.9	11.1	64.5	75.6	12.8	75.3	88.1
WORLD	139.2	969.3	1108.5	138.0	1139.8	1277.8	135.2	1313.7	1448.9

Table A11 : Calcium Formate Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies		50.8	50.8		55.1	55.1		59.3	59.3
CPE Europe (incl USSR)		23.8	23.8		28.0	28.0		32.3	32.3
Developing Market Economies		47.5	47.5		60.3	60.3		73.5	73.5
Sub-Saharan Africa		2.0	2.0		2.7	2.7		3.8	3.8
North Africa and West Asia		4.8	4.8		7.6	7.6		10.4	10.4
South Asia		15.0	15.0		18.4	18.4		21.9	21.9
South East Asia		4.6	4.6		5.5	5.5		6.4	6.4
Latin America		21.1	21.1		26.1	26.1		31.0	31.0
CPE Asia		7.1	7.1		8.6	8.6		10.0	10.0
WORLD		129.2	129.2		152.0	152.0		175.1	175.1

Table A12 : Sulphuric acid (con) 96% Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies	10.6	101.6	112.2	9.5	110.3	119.8	9.0	118.6	127.6
CPE Europe (incl USSR)	11.9	47.5	59.4	10.3	56.0	66.3	7.7	64.6	72.3
Developing Market Economies	11.9	95.1	107.0	14.0	120.4	134.4	15.9	147.0	162.9
Sub-Saharan Africa	0.1	4.0	4.1	0.2	5.3	5.5	0.2	7.5	7.7
North Africa and West Asia	1.7	9.6	11.3	1.9	15.1	17.0	2.2	20.8	23.0
South Asia	4.3	30.1	34.4	5.3	36.8	42.1	6.2	43.7	49.9
South East Asia	1.3	9.1	10.4	1.7	11.0	12.7	2.1	12.9	15.0
Latin America	4.5	42.3	46.8	4.9	52.2	57.1	5.2	62.1	67.3
CPE Asia	2.7	14.3	17.0	3.0	17.2	20.2	3.4	20.1	23.5
WORLD	37.1	258.5	295.6	36.8	303.9	340.7	36.0	350.3	386.3

Table A13 : Sodium Carbonate Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies		50.8	50.8		55.1	55.1		59.3	59.3
CPE Europe (incl USSR)		23.8	23.8		28.0	28.0		32.3	32.3
Developing Market Economies		47.5	47.5		60.3	60.3		73.5	73.5
Sub-Saharan Africa		2.0	2.0		2.7	2.7		3.8	3.8
North Africa and West Asia		4.8	4.8		7.6	7.6		10.4	10.4
South Asia		15.0	15.0		18.4	18.4		21.9	21.9
South East Asia		4.6	4.6		5.5	5.5		6.4	6.4
Latin America		21.1	21.1		26.1	26.1		31.0	31.0
CPE Asia		7.1	7.1		8.6	8.6		10.0	10.0
WORLD		129.2	129.2		152.0	152.0		175.1	175.1

Table A14: Sodium Sulphite Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies		50.8	50.8		55.1	55.1		59.3	59.3
CPE Europe (incl USSR)		23.8	23.8		28.0	28.0		32.3	32.3
Developing Market Economies		47.5	47.5		60.3	60.3		73.5	73.5
Sub-Saharan Africa		2.0	2.0		2.7	2.7		3.8	3.8
North Africa and West Asia		4.8	4.8		7.6	7.6		10.4	10.4
South Asia		15.0	15.0		18.4	18.4		21.9	21.9
South East Asia		4.6	4.6		5.5	5.5		6.4	6.4
Latin America		21.1	21.1		26.1	26.1		31.0	31.0
CPE Asia		7.1	7.1		8.6	8.6		10.0	10.0
WORLD		129.2	129.2		152.0	152.0		175.1	175.1

Table A15 : Chrome Salts Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies		253.9	253.9		275.7	275.7		296.6	296.6
CPE Europe (incl USSR)		118.8	118.8		140.1	140.1		161.5	161.5
Developing Market Economies		237.8	237.8		301.1	301.1		367.5	367.5
Sub-Saharan Africa		10.0	10.0		13.3	13.3		18.8	18.8
North Africa and West Asia		24.0	24.0		37.8	37.8		52.0	52.0
South Asia		75.2	75.2		92.0	92.0		109.3	109.3
South East Asia		22.9	22.9		27.6	27.6		32.1	32.1
Latin America		105.7	105.7		130.4	130.4		155.3	155.3
CPE Asia		35.7	35.7		43.0	43.0		50.2	50.2
WORLD		646.2	646.2		759.9	759.9		875.8	875.8

Table A16 : Vegetable Tanning Materials Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies	31.7	76.2	107.9	28.6	82.7	111.3	27.1	89.0	116.1
CPE Europe (incl USSR)	35.8	35.6	71.4	30.9	42.1	73.0	23.2	48.4	71.6
Developing Market Economies	35.6	71.3	106.9	42.0	90.3	132.3	47.6	110.2	157.8
Sub-Saharan Africa	0.4	3.0	3.4	0.5	4.0	4.5	0.7	5.6	6.3
North Africa and West Asia	5.0	7.2	12.2	5.9	11.3	17.2	6.6	15.6	22.2
South Asia	12.7	22.5	35.2	15.8	27.6	43.4	18.7	32.8	51.5
South East Asia	4.0	6.9	10.9	5.2	8.3	13.5	6.1	9.6	15.7
Latin America	13.5	31.7	45.2	14.6	39.1	53.7	15.5	46.6	62.1
CPE Asia	8.3	10.7	19.0	8.9	12.9	21.8	10.2	15.1	25.3
WORLD	111.4	193.8	305.2	110.4	228.0	338.4	108.1	262.7	370.8

Table A17 : Bates Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies	2.1	20.3	22.4	1.9	22.1	24.0	1.8	23.7	25.5
CPE Europe (incl USSR)	2.4	9.5	11.9	2.1	11.2	13.3	1.5	12.9	14.4
Developing Market Economies	2.4	19.0	21.4	2.8	24.1	26.9	3.2	29.4	32.6
Sub-Saharan Africa	...	0.8	0.8	...	1.1	1.1	0.1	1.5	1.6
North Africa and West Asia	0.3	1.9	2.2	0.4	3.0	3.4	0.4	4.2	4.6
South Asia	0.9	6.0	6.9	1.1	7.4	8.5	1.3	8.7	10.0
South East Asia	0.3	1.8	2.1	0.3	2.2	2.5	0.4	2.6	3.0
Latin America	0.9	8.5	9.4	1.0	10.4	11.4	1.0	12.4	13.4
CPE Asia	0.5	2.9	3.4	0.6	3.4	4.0	0.7	4.0	4.7
WORLD	7.4	51.7	59.1	7.4	60.8	68.2	7.2	70.0	77.2

Table A18 : Bactericides Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies	0.8	7.6	8.4	0.7	8.3	9.0	0.7	8.9	9.6
CPE Europe (incl USSR)	0.9	3.6	4.5	0.8	4.2	5.0	0.6	4.8	5.4
Developing Market Economies	0.9	7.1	8.0	1.1	9.0	10.1	1.2	11.0	12.2
Sub-Saharan Africa	...	0.3	0.3	...	0.4	0.4	...	0.5	0.5
North Africa and West Asia	0.1	0.7	0.8	0.2	1.1	1.3	0.2	1.5	1.7
South Asia	0.3	2.2	2.5	0.4	2.8	3.2	0.5	3.3	3.8
South East Asia	0.1	0.7	0.8	0.1	0.8	0.9	0.1	1.0	1.1
Latin America	0.4	3.2	3.6	0.4	3.9	4.3	0.4	4.7	5.1
CPE Asia	0.2	1.1	1.3	0.2	1.3	1.5	0.2	1.6	1.8
WORLD	2.8	19.4	22.2	2.8	22.8	25.6	2.7	26.3	29.0

... indicates a value of less than 50 tons

Table A19 : Syntans Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies		76.2	76.2		82.7	82.7		89.0	89.0
CPE Europe (incl USSR)		35.6	35.6		42.1	42.1		48.4	48.4
Developing Market Economies		71.3	71.3		90.3	90.3		110.2	110.2
Sub-Saharan Africa		3.0	3.0		4.0	4.0		5.6	5.6
North Africa and West Asia		7.2	7.2		11.3	11.3		15.6	15.6
South Asia		22.5	22.5		27.6	27.6		32.8	32.8
South East Asia		6.9	6.9		8.3	8.3		9.6	9.6
Latin America		31.7	31.7		39.1	39.1		46.6	46.6
CPE Asia		10.7	10.7		12.9	12.9		15.1	15.1
WORLD		193.8	193.8		228.0	228.0		262.7	262.7

Table A20 : Fatliquors Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies		101.6	101.6		110.3	110.3		118.6	118.6
CPE Europe (incl USSR)		47.5	47.5		56.0	56.0		64.6	64.6
Developing Market Economies		95.1	95.1		120.4	120.4		147.0	147.0
Sub-Saharan Africa		4.0	4.0		5.3	5.3		7.5	7.5
North Africa and West Asia		9.6	9.6		15.1	15.1		20.8	20.8
South Asia		30.1	30.1		36.8	36.8		43.7	43.7
South East Asia		9.1	9.1		11.0	11.0		12.9	12.9
Latin America		42.3	42.3		52.2	52.2		62.1	62.1
CPE Asia		14.3	14.3		17.2	17.2		20.1	20.1
WORLD		258.5	258.5		303.9	303.9		350.3	350.3

Table A21 : Dyeing Auxiliaries Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies		67.5	67.5		73.3	73.3		78.9	78.9
CPE Europe (incl USSR)		31.6	31.6		37.3	37.3		43.0	43.0
Developing Market Economies		63.3	63.3		80.1	80.1		97.8	97.8
Sub-Saharan Africa		2.7	2.7		3.5	3.5		5.0	5.0
North Africa and West Asia		6.4	6.4		10.1	10.1		13.8	13.8
South Asia		20.0	20.0		24.5	24.5		29.1	29.1
South East Asia		6.1	6.1		7.3	7.3		8.6	8.6
Latin America		28.1	28.1		34.7	34.7		41.3	41.3
CPE Asia		9.5	9.5		11.4	11.4		13.3	13.3
WORLD		171.9	171.9		202.1	202.1		233.0	233.0

Table A22 : Dyes Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies		10.6	10.6		11.6	11.6		12.5	12.5
CPE Europe (incl USSR)		5.0	5.0		5.9	5.9		6.8	6.8
Developing Market Economies		10.0	10.0		12.6	12.6		15.4	15.4
Sub-Saharan Africa		0.4	0.4		0.5	0.5		0.8	0.8
North Africa and West Asia		1.0	1.0		1.6	1.6		2.2	2.2
South Asia		3.2	3.2		3.8	3.8		4.6	4.6
South East Asia		1.0	1.0		1.2	1.2		1.3	1.3
Latin America		4.4	4.4		5.5	5.5		6.5	6.5
CPE Asia		1.5	1.5		1.8	1.8		2.1	2.1
WORLD		27.1	27.1		31.9	31.9		36.8	36.8

Table A23 : Finishes Required for Leather Production, 1980 to 2000

thousand tons

	1980			1990			2000		
	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total	Heavy Leather	Light Leather	Total
Developed Market Economies		76.4	76.4		83.0	83.0		89.3	89.3
CPE Europe (incl USSR)		35.8	35.8		42.2	42.2		48.6	48.6
Developing Market Economies		71.5	71.5		90.6	90.6		110.6	110.6
Sub-Saharan Africa		3.0	3.0		4.0	4.0		5.7	5.7
North Africa and West Asia		7.2	7.2		11.4	11.4		15.6	15.6
South Asia		22.6	22.6		27.7	27.7		32.9	32.9
South East Asia		6.9	6.9		8.3	8.3		9.7	9.7
Latin America		31.8	31.9		39.2	39.2		46.7	46.7
CPE Asia		10.8	10.8		12.9	12.9		15.1	15.1
WORLD		194.5	194.5		228.7	228.7		263.6	263.6

Source: Table A5 to A23, special estimates for this study.

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Q U E S T I O N N A I R E

Strategies for increasing the production of tanning chemicals in developing countries

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